

there are only limited opportunities for a controller to switch from a position in an enroute center to a tower.

Job Outlook

Extremely keen competition is expected for air traffic controller jobs because the occupation attracts many more qualified applicants than the small number of job openings that result from replacement needs. Turnover is very low because of the relatively high pay and liberal retirement benefits, and controllers have a very strong attachment to the occupation. Most of the current work force was hired as a result of the controller's strike during the 1980's, so the average age of current controllers is fairly young. Relatively few controllers will be eligible to retire over the 1998-2008 period.

Employment of air traffic controllers is expected to show little or no change through the year 2008. Employment growth is not expected to keep pace with growth in the number of aircraft flying because of the implementation of a new air traffic control system over the next 10 years. This computerized system will assist the controller by automatically making many of the routine decisions. Automation will allow controllers to handle more traffic, thus increasing their productivity.

Air traffic controllers who continue to meet the proficiency and medical requirements enjoy more job security than most workers. The demand for air travel and the workloads of air traffic controllers decline during recessions, but controllers seldom are laid off.

Earnings

Median annual earnings of air traffic controllers in 1998 were \$64,880. The middle 50 percent earned between \$50,980 and

\$78,840. The lowest 10 percent earned less than \$36,640 and the highest 10 percent earned more than \$87,210.

The average annual salary for air traffic controllers in the Federal Government—which employs 86 percent of the total—in nonsupervisory, supervisory, and managerial positions was \$48,300 in 1999. Both the worker's job responsibilities and the complexity of the particular facility determine a controller's pay. For example, controllers who work at the FAA's busiest air traffic control facilities earn higher pay.

Depending on length of service, air traffic controllers receive 13 to 26 days of paid vacation and 13 days of paid sick leave each year, life insurance, and health benefits. In addition, controllers can retire at an earlier age and with fewer years of service than other Federal employees. Air traffic controllers are eligible to retire at age 50 with 20 years of service as an active air traffic controller or after 25 years of active service at any age. There is a mandatory retirement age of 56 for controllers who manage air traffic.

Related Occupations

Other occupations that involve the direction and control of traffic in air transportation are airline-radio operator and airplane dispatcher.

Sources of Additional Information

Information on acquiring a job as an air traffic controller with the Federal Government may be obtained from the Office of Personnel Management (OPM) through a telephone-based system. Consult your telephone directory under U.S. Government for a local number or call (912) 757-3000; TDD (912) 744-2299. That number is not toll free and charges may result. Information also is available from their Internet site: <http://www.usajobs.opm.gov>

Engineers

Significant Points

- A bachelor's degree is required for entry-level jobs.
- Starting salaries are significantly higher than those of college graduates in other fields.
- Continuing education is critical to keep abreast of the latest technology.

Nature of the Work

Engineers apply the theories and principles of science and mathematics to research and develop economical solutions to technical problems. Their work is the link between scientific discoveries and commercial applications. Engineers design products, machinery to build those products, factories in which those products are made, and the systems that ensure the quality of the product and efficiency of the workforce and manufacturing process. Engineers design, plan, and supervise the construction of buildings, highways, and transit systems. They develop and implement improved ways to extract, process, and use raw materials, such as petroleum and natural gas. They develop new materials that both improve the performance of products and help implement advances in technology. They harness the power of the sun, the Earth, atoms, and electricity for use in supplying the Nation's power needs, and create millions of products using power. Engineering knowledge is applied to improving many things, including the quality of health care, the safety of food products, and the efficient operation of financial systems.

Engineers consider many factors when developing a new product. For example, in developing an industrial robot, engineers determine precisely what function the robot needs to perform; design and test the robot's components; fit the components together in an integrated plan; and evaluate the design's overall effectiveness, cost,

reliability, and safety. This process applies to many different products, such as chemicals, computers, gas turbines, helicopters, and toys.

In addition to design and development, many engineers work in testing, production, or maintenance. These engineers supervise production in factories, determine the causes of breakdowns, and test manufactured products to maintain quality. They also estimate the time and cost to complete projects. Some work in engineering management or in sales, where an engineering background enables them to discuss technical aspects and assist in product planning, installation, and use. (See the statements on engineering, natural science, and computer and information systems managers, and manufacturers' and wholesale sales representatives, elsewhere in the *Handbook*.)

Most engineers specialize. More than 25 major specialties are recognized by professional societies, and the major branches have numerous subdivisions. Some examples include structural, environmental, and transportation engineering, which are subdivisions of civil engineering; and ceramic, metallurgical, and polymer engineering, which are subdivisions of materials engineering. Engineers may also specialize in one industry such as motor vehicles or in one field of technology, such as jet engines or semiconductor materials.

This section, which contains an overall discussion of engineering, is followed by separate sections on 10 engineering branches: Aerospace, chemical, civil, electrical and electronics, industrial, materials, mechanical, mining, nuclear, and petroleum engineering. (Computer engineers are discussed in the statement on computer systems analysts, engineers, and scientists elsewhere in the *Handbook*.) Some branches of engineering not covered in detail here, but for which there are established college programs, include architectural engineering—the design of a building's internal support structure; biomedical engineering—the application of engineering

to medical and physiological problems; environmental engineering—a growing discipline involved with identifying, solving, and alleviating environmental problems; and marine engineering—the design and installation of ship machinery and propulsion systems.

Engineers in each branch have a base of knowledge and training that can be applied in many fields. Electrical and electronics engineers, for example, work in the medical, computer, missile guidance, and power distribution fields. Because there are many separate problems to solve in a large engineering project, engineers in one field often work closely with specialists in other scientific, engineering, and business occupations.

Engineers use computers to produce and analyze designs; to simulate and test how a machine, structure, or system operates; and to generate specifications for parts. Many engineers also use computers to monitor product quality and control process efficiency. They spend a great deal of time writing reports and consulting with other engineers, as complex projects often require an interdisciplinary team of engineers. Supervisory engineers are responsible for major components or entire projects.

Working Conditions

Most engineers work in office buildings, laboratories, or industrial plants. Others may spend time outdoors at construction sites, mines, and oil and gas exploration sites, where they monitor or direct operations or solve onsite problems. Some engineers travel extensively to plants or work sites.

Many engineers work a standard 40-hour week. At times, deadlines or design standards may bring extra pressure to a job. When this happens, engineers may work longer hours and experience considerable stress.

Employment

In 1998, engineers held 1.5 million jobs. The following tabulation shows the distribution of employment by engineering specialty.

<i>Specialty</i>	<i>Employment</i>	<i>Percent</i>
Total, all engineers	1,462,000	100.0
Electrical and electronics	357,000	24
Mechanical	220,000	15
Civil	195,000	13
Industrial	126,000	9
Aerospace	53,000	4
Chemical	48,000	3
Materials	20,000	1
Petroleum	12,000	<1
Nuclear	12,000	<1
Mining	4,000	<1
All other engineers	415,000	28

Almost half of all wage and salary engineering jobs were found in manufacturing industries, such as transportation equipment, electrical and electronic equipment, industrial machinery, and instruments and related products. In 1998, about 390,000 wage and salary jobs were in services industries, primarily in engineering and architectural services, research and testing services, and business services, where firms designed construction projects or did other engineering work on a contractual basis. Engineers also worked in the communications, utilities, and construction industries.

Federal, State and local governments employed about 166,000 wage and salary engineers in 1998. Over half of these were in the Federal Government, mainly in the Departments of Defense, Transportation, Agriculture, Interior, and Energy, and in the National Aeronautics and Space Administration. Most engineers in State and local government agencies worked in highway and public works departments. In 1998, about 50,000 engineers were self-employed, many as consultants.

Engineers are employed in every State, in small and large cities, and in rural areas. Some branches of engineering are concentrated in particular industries and geographic areas, as discussed in statements later in this chapter.

Training, Other Qualifications, and Advancement

A bachelor's degree in engineering is generally required for entry-level engineering jobs. College graduates with a degree in a physical science or mathematics may occasionally qualify for some engineering jobs, especially in specialties in high demand. Most engineering degrees are granted in electrical, mechanical, or civil engineering. However, engineers trained in one branch may work in related branches. For example, many aerospace engineers have training in mechanical engineering. This flexibility allows employers to meet staffing needs in new technologies and specialties in which engineers are in short supply. It also allows engineers to shift to fields with better employment prospects or to ones that match their interests more closely.

In addition to the standard engineering degree, many colleges offer degrees in engineering technology, which are offered as either 2- or 4-year programs. These programs prepare students for practical design and production work, rather than for jobs that require more theoretical and scientific knowledge. Graduates of 4-year technology programs may get jobs similar to those obtained by graduates with a bachelor's degree in engineering. Some employers regard technology program graduates as having skills between those of a technician and an engineer.

Graduate training is essential for engineering faculty positions, but is not required for the majority of entry-level engineering jobs. Many engineers obtain graduate degrees in engineering or business administration to learn new technology, broaden their education, and enhance their promotion opportunities. Many high-level executives in government and industry began their careers as engineers.

About 320 colleges and universities offer bachelor's degree programs in engineering that are accredited by the Accreditation Board for Engineering and Technology (ABET), and about 250 colleges offer accredited bachelor's degree programs in engineering technology. ABET accreditation is based on an examination of an engineering program's student achievement, program improvement, faculty, curricular content, facilities, and institutional commitment. Although most institutions offer programs in the major branches of engineering, only a few offer some of the smaller specialties. Also, programs of the same title may vary in content. For example, some programs emphasize industrial practices, preparing students for a job in industry, whereas others are more theoretical and are better for students preparing to take graduate work. Therefore, students should investigate curricula and check accreditations carefully before selecting a college. Admissions requirements for undergraduate engineering schools include a solid background in mathematics (algebra, geometry, trigonometry, and calculus), sciences (biology, chemistry, and physics), and courses in English, social studies, humanities, and computers.

Bachelor's degree programs in engineering are typically designed to last 4 years, but many students find that it takes between 4 and 5 years to complete their studies. In a typical 4-year college curriculum, the first 2 years are spent studying mathematics, basic sciences, introductory engineering, humanities, and social sciences. In the last 2 years, most courses are in engineering, usually with a concentration in one branch. For example, the last 2 years of an aerospace program might include courses such as fluid mechanics, heat transfer, applied aerodynamics, analytical mechanics, flight vehicle design, trajectory dynamics, and aerospace propulsion systems. Some programs offer a general engineering curriculum; students then specialize in graduate school or on the job.

Some engineering schools and 2-year colleges have agreements whereby the 2-year college provides the initial engineering educa-

tion; and the engineering school automatically admits students for their last 2 years. In addition, a few engineering schools have arrangements, whereby a student spends 3 years in a liberal arts college studying pre-engineering subjects and 2 years in an engineering school studying core subjects, and then receives a bachelor's degree from each school. Some colleges and universities offer 5-year master's degree programs. Some 5- or even 6-year cooperative plans combine classroom study and practical work, permitting students to gain valuable experience and finance part of their education.

All 50 States and the District of Columbia require licensure for engineers whose work may affect life, health, or property, or who offer their services to the public. Engineers who are licensed are called Professional Engineers (PE). This licensure generally requires a degree from an ABET-accredited engineering program, 4 years of relevant work experience, and successful completion of a State examination. Recent graduates can start the licensing process by taking the examination in two stages. The initial examination can be taken upon graduation. Engineers who pass this examination are commonly called Engineers in Training (EIT). The EIT certification is usually valid for 10 years. After acquiring suitable work experience, EITs can take the second examination, the Principles and Practice of Engineering Exam. While Professional Engineers must be licensed in each State in which they practice, most states recognize licensure from other states. Many civil, electrical, mechanical, and chemical engineers are certified as PEs.

Engineers should be creative, inquisitive, analytical, and detail-oriented. They should be able to work as part of a team and be able to communicate well, both orally and in writing.

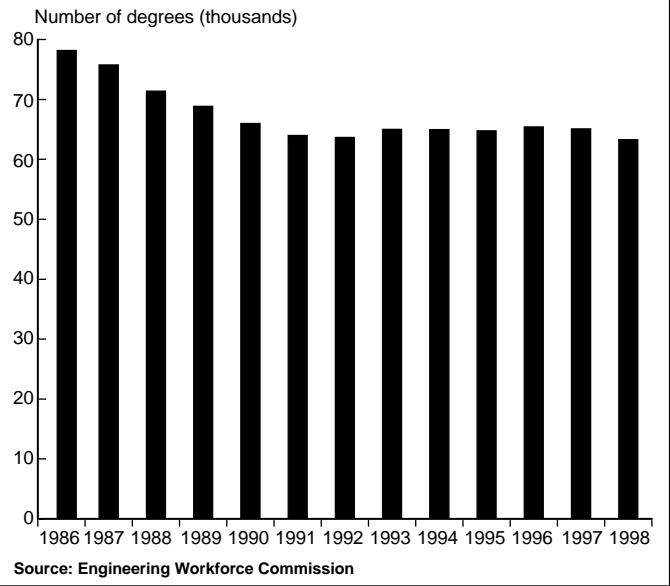
Beginning engineering graduates usually work under the supervision of experienced engineers and, in large companies, may also receive formal classroom or seminar-type training. As new engineers gain knowledge and experience, they are assigned more difficult projects with greater independence to develop designs, solve problems, and make decisions. Engineers may advance to become technical specialists or to supervise a staff or team of engineers and technicians. Some eventually become engineering managers or enter other managerial or sales jobs. (See the statements under executive, administrative, and managerial occupations, and under marketing and sales occupations, elsewhere in the *Handbook*.)

Job Outlook

Employment opportunities in engineering are expected to be good through 2008. Overall engineering employment is expected to increase about as fast as the average for all occupations, while the number of engineering degrees granted has remained fairly constant over the past several years. Projected growth varies by specialty, ranging from a decline among mining engineers to faster-than-average growth among electrical and electronics engineers. Competitive pressures and advancing technology will force companies to improve and update product designs increasingly more frequently, and to optimize their manufacturing processes. Employers will rely on engineers to further increase productivity, as investment in plant and equipment increases to expand output of goods and services. New computer systems have improved the design process, enabling engineers to produce and analyze various product designs much more rapidly than in the past. Despite these widespread applications, computer technology is not expected to limit employment opportunities. Finally, additional engineers will be needed to improve or build new roads, bridges, water and pollution control systems, and other public facilities.

Many engineering jobs are related to developing technologies used in national defense. Because defense expenditures—particularly expenditures for aircraft, missiles, and other weapons systems—are not expected to return to previously high levels, job outlook may not be as favorable for engineers working in defense-related fields.

The number of bachelor's degrees awarded in engineering has declined since 1986.



The number of bachelor's degrees awarded in engineering began declining in 1987, as shown in the accompanying chart, and has continued to stay at about the same level through much of the 1990s. Although it is difficult to project engineering enrollments, the total number of graduates from engineering programs is not expected to increase significantly over the projection period. Some engineering schools have restricted enrollments, especially in defense-related fields, such as aerospace engineering, to accommodate reduced job opportunities.

Although only a relatively small proportion of engineers leaves the profession each year, many job openings will arise from replacement needs. A greater proportion of replacement openings is created by engineers who transfer to management, sales, or other professional specialty occupations than by those who leave the labor force.

Most industries are less likely to lay off engineers than other workers. Many engineers work on long-term research and development projects or in other activities that continue even during economic slowdowns. In industries such as electronics and aerospace, however, large cutbacks in defense expenditures and government research and development funds, as well as the trend toward contracting out engineering work to engineering services firms, have resulted in significant layoffs for engineers.

It is important for engineers, like those working in other technical occupations, to continue their education throughout their careers, because much of their value to their employer depends on their knowledge of the latest technology. Although the pace of technological change varies by engineering specialty and industry, advances in technology have affected every engineering discipline significantly. Engineers in high-technology areas, such as advanced electronics, may find that technical knowledge can become obsolete rapidly. Even those who continue their education are vulnerable if the particular technology or product in which they have specialized becomes obsolete. By keeping current in their field, engineers are able to deliver the best solutions and greatest value to their employers. Engineers who have not kept current in their field may find themselves passed over for promotions or vulnerable to layoffs, should they occur. On the other hand, it is often these high-technology areas that offer the greatest challenges, the most interesting work, and the highest salaries. Therefore, the

choice of engineering specialty and employer involves an assessment not only of the potential rewards but also of the risk of technological obsolescence.

Related Occupations

Engineers apply the principles of physical science and mathematics in their work. Other workers who use scientific and mathematical principles include engineering, natural science, and computer and information systems managers; physical and life scientists; mathematicians; computer systems analysts, engineers, and scientists; engineering and science technicians; and architects.

Sources of Additional Information

High school students interested in obtaining general information on a variety of engineering disciplines should contact the Junior Engineering Technical Society, by sending a self-addressed business-size envelope with six first-class stamps affixed to:

✦ JETS-Guidance, at 1420 King St., Suite 405, Alexandria, VA 22314-2794. Internet: <http://www.jets.org>

High school students interested in obtaining information on ABET-accredited engineering programs should contact:

✦ The Accreditation Board for Engineering and Technology, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202-4012.

Internet: <http://www.abet.org>

College students interested in obtaining information on Professional Engineer licensure should contact:

✦ The National Society of Professional Engineers, 1420 King St., Alexandria, VA 22314-2794. Internet: <http://www.nspe.org>

Information on obtaining an engineering position with the Federal Government is available from the Office of Personnel Management through a telephone-based system. Consult your telephone directory under U.S. Government for a local number or call (912) 757-3000; TDD (912) 744-2299. That number is not toll free, and charges may result. Information is also available from the Internet site: <http://www.usajobs.opm.gov>

Non-high school students and those wanting more detailed information should contact societies representing the individual branches of engineering. Each can provide information about careers in the particular branch.

Aerospace Engineering

✦ Aerospace Industries Association, 1250 Eye St., NW., Washington, DC 20005. Internet: <http://www.aiaa-aerospace.org>

✦ American Institute of Aeronautics and Astronautics, Inc., Suite 500, 1801 Alexander Bell Dr., Reston, VA 20191-4344. Enclose \$2 to receive guidance materials and information.

Internet: <http://www.aiaa.org>

Chemical Engineering

✦ American Institute of Chemical Engineers, Three Park Ave., New York, NY 10016-5901. Internet: <http://www.aiche.org>

✦ American Chemical Society, Department of Career Services, 1155 16th St. NW., Washington, DC 20036. Internet: <http://www.acs.org>

Civil Engineering

✦ American Society of Civil Engineers, 1801 Alexander Bell Dr., Reston, VA 20191-4400. Internet: <http://www.asce.org>

Electrical and Electronics Engineering

✦ Institute of Electrical and Electronics Engineers—United States of America, 1828 L St. NW., Suite 1202, Washington, DC 20036. Internet: <http://www.ieee-usa.org>

Industrial Engineering

✦ Institute of Industrial Engineers, Inc., 25 Technology Park/Atlanta, Norcross, GA 30092. Internet: <http://www.iienet.org>

Materials Engineering

✦ The Minerals, Metals, & Materials Society, 184 Thorn Hill Rd., Warrendale, PA 15086. Internet: <http://www.tms.org>

✦ ASM International Foundation, Materials Park, OH 44073-0002. Internet: <http://www.asm-intl.org>

Mechanical Engineering

✦ The American Society of Mechanical Engineers, Three Park Ave., New York, NY 10016. Internet: <http://www.asme.org>

✦ American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle NE, Atlanta, GA 30329. Internet: <http://www.ashrae.org>

Mining Engineering

✦ The Society for Mining, Metallurgy, and Exploration, Inc., P.O. Box 625002, Littleton, CO 80162-5002. Internet: <http://www.smenet.org>

Nuclear Engineering

✦ American Nuclear Society, 555 North Kensington Ave., LaGrange Park, IL 60525. Internet: <http://www.ans.org>

Petroleum Engineering

✦ Society of Petroleum Engineers, P.O. Box 833836, Richardson, TX 75083-3836. Internet: <http://www.spe.org>

Aerospace Engineers

(O*NET 22102)

Nature of the Work

Aerospace engineers are responsible for developing extraordinary machines, from airplanes that weigh over a half a million pounds to spacecraft that travel over 17,000 miles an hour. They design, develop, and test aircraft, spacecraft, and missiles and supervise manufacturing of these products. Aerospace engineers who work with aircraft are considered *aeronautical engineers*, and those working specifically with spacecraft are considered *astronautical engineers*.

Aerospace engineers develop new technologies for use in aviation, defense systems, and space exploration, often specializing in areas like structural design, guidance, navigation and control, instrumentation and communication, or production methods. They also may specialize in a particular type of aerospace product, such as commercial transports, military fighter jets, helicopters, spacecraft, or missiles and rockets. Aerospace engineers may be experts in aerodynamics, thermodynamics, celestial mechanics, propulsion, acoustics, or guidance and control systems.

Employment

Aerospace engineers held about 53,000 jobs in 1998. Almost one-half worked in the aircraft and parts and guided missile and space vehicle manufacturing industries. Federal Government agencies, primarily the Department of Defense and the National Aeronautics and Space Administration, provided about 1 out of 7 jobs. Business services, engineering and architectural services, research and testing services, and electrical and electronics manufacturing firms accounted for most of the remaining jobs.

California, Washington, Texas, and Florida—States with large aerospace manufacturers—employ the most aerospace engineers.

Job Outlook

Those seeking employment as aerospace engineers are likely to face keen competition because the supply of graduates is expected to exceed the number of job openings. Employment of aerospace engineers is expected to grow more slowly than the average for all occupations through 2008. The decline in Defense Department expenditures for military aircraft, missiles, and other aerospace systems has caused mergers and acquisitions among defense contractors. In addition,